

# **INDOOR AIR QUALITY ASSESSMENT**

**Duxbury Free Library  
77 Alden Street  
Duxbury, Massachusetts**



Prepared by:  
Massachusetts Department of Public Health  
Center for Environmental Health  
Bureau of Environmental Health Assessment  
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## **Background/Introduction**

At the request of Elaine Wynquist, Director of the Duxbury Free Library (DFL), the Massachusetts Department of Public Health's (MDPH) Center for Environmental Health (CEH) provided assistance and consultation regarding indoor air quality concerns at the DFL, located at 77 Alden Street, Duxbury, MA. On January 12, 2005 a visit to conduct an assessment was made to the DFL by Cory Holmes, an Environmental Analyst in CEH's Emergency Response/Indoor Air Quality (ER/IAQ) Program. Mr. Holmes was accompanied by Ms. Wynquist for portions of the assessment.

The DFL is a three-story brick structure, with a finished basement originally constructed as a high school in 1926. An addition was reportedly appended to the original building in the 1960s. The building was converted to a library and underwent extensive renovations in 1996-1997. The main floor of the library contains the circulation desk, main office, open stack areas, restrooms, and computer stations. The basement contains an auditorium, kitchen/break room, boiler room and storage area. The second floor contains a reference section, young adult area and administrative offices. The attic contains heating, ventilation and air conditioning (HVAC) equipment. Windows are openable throughout the building.

## **Methods**

Air tests for carbon dioxide, carbon monoxide, temperature and relative humidity with the TSI, Q-TRAK™ IAQ Monitor, Model 8551. MDPH staff also performed a visual inspection of building materials for water damage and/or microbial growth. Moisture

content of porous building materials (e.g., carpeting, insulation, ceiling tiles) was measured with Delmhorst, BD-2000 Model, Moisture Detector with a Delmhorst Standard Probe.

## **Results**

The DFL has approximately 25 employees with up to 300-400 members of the public visiting on a daily basis. Tests were taken during normal operations and results appear in Table 1.

## **Discussion**

### **Ventilation**

It can be seen from the tables that carbon dioxide levels were below 800 parts per million parts (ppm) of air in all areas surveyed, indicating adequate ventilation at the time of the assessment. However, it is important to note that most areas were sparsely populated, which would contribute to reduced carbon dioxide levels. Carbon dioxide levels would be expected to rise during increased occupation.

The building has a heating, ventilating and air conditioning (HVAC) system, which consists of three air handling units (AHUs) equipped with high efficiency pleated air filters (Pictures 1 and 2). Conditioned outside air is provided through ducted wall or ceiling vents and is returned to the AHUs by ducted ceiling-mounted return vents, which are also equipped with high efficiency-pleated filters (Picture 3) providing dual filtration. This system was operating throughout the building on the day of the assessment. Thermostats that control the HVAC system have fan settings of “on” and “automatic”. Thermostats set to the “automatic” setting were observed during the assessment (Picture 4). The automatic

setting on the thermostat activates the HVAC system at a preset temperature. Once the preset temperature is reached, the HVAC system is deactivated. Therefore, no mechanical ventilation is provided until the thermostat re-activates the system.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of occupancy. In order to have proper ventilation with a mechanical ventilation system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that HVAC systems be re-balanced every five years (SMACNA, 1994). The date of the last systems balancing should have occurred when building renovations were completed in 1997. Ms. Winquist reported that DFL staff has been working with their HVAC vendor over the last year to rebalance the system, due to employee comfort issues.

The Massachusetts Building Code requires a minimum ventilation rate of 20 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (BOCA, 1993; SBBRS, 1997). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health

Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information on carbon dioxide see [Appendix A](#).

Temperature measurements ranged from 65° F to 72° F, which were below or near the lower range of the MDPH comfort guidelines. The MDPH recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the comfort of building occupants. Temperature control complaints in a number of areas were expressed to MDPH staff during the assessment. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. As discussed, DFL staff have been and continue to work with their HVAC vendor to identify and correct areas where temperature control is problematic.

The relative humidity measured in the building ranged from 26 to 38 percent, which was below or slightly below the lower end of the MDPH recommended comfort range. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the

winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

### **Microbial/Moisture Concerns**

Water-damaged building materials (e.g., wood, gypsum wallboard/Pictures 5-9) and efflorescence were observed in the attic and on the second floor. Water damage is most likely the result of water penetration through the building envelope primarily on the north facing wall (Picture 10). Efflorescence is a characteristic sign of water damage to brick and mortar, but it is not mold growth. As moisture penetrates and works its way through mortar and brick, water-soluble compounds in mortar and brick dissolve, creating a solution. As the solution moves to the surface of the mortar or brick, the water evaporates, leaving behind white, powdery mineral deposits.

Water-damaged building materials can provide a source of mold and should be replaced after a water leak is discovered and repaired. Repeated water damage to porous building materials (e.g., gypsum wallboard, ceiling tiles, wood) can result in microbial growth. The US Environmental Protection Agency (US EPA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommend that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur.

In order for building materials to support mold growth, a source of moisture is necessary. Identification and elimination of water moistening building materials is

necessary to control mold growth. Materials with increased moisture content over normal concentrations may indicate the possible presence of mold growth. Identification of the location of materials with increased moisture levels can also provide clues concerning the source of water supporting mold growth. In an effort to ascertain moisture content of building materials, samples were taken in areas most likely impacted by water damage. A number of non-affected areas were measured for comparison (Table 1).

The Delmhorst probe is equipped with three lights as visual aids to determine moisture level. Readings that activate the green light indicate a sufficiently dry or low moisture level, those that activate the yellow light indicate borderline conditions and those that activate the red light indicate elevated moisture content. Elevated moisture content was detected in the wooden floor of the attic. The day of the assessment occurred on a windy day with heavy to moderate rainfall and water penetration through the north-facing brickwork in the attic was evident.

MDPH staff examined the building exterior and observed several downspouts missing from the drainage/gutter system (Picture 11 and 12). Pooling water and excessive exposure of exterior brickwork to water can result in damage over time. Mortar around exterior brickwork appeared to be crumbling or missing in some areas (Pictures 13 and 14). During winter weather, the freezing and thawing of moisture in bricks can accelerate the deterioration of brickwork. Damaged brickwork can become a point of water intrusion.

### **Other Concerns**

Several other conditions that can affect indoor air quality were noted during the assessment. Libraries in general, have a large number of flat and irregular surfaces (e.g.,

book shelves, books) that provide a source for dusts to accumulate and are difficult for custodial staff to clean. Dust can be irritating to eyes, nose and respiratory tract. Items should be removed and/or be cleaned periodically to avoid excessive dust build up.

## **Conclusions/Recommendations**

In view of the findings at the time of the visit, the following recommendations are made:

1. Consider repointing brickwork on the north-facing wall. Consider consulting an architect, masonry firm or general contractor regarding the integrity of the building envelope, primarily concerning water penetration through exterior walls. Ensure all leaks are repaired. Once leaks are repaired, repair water-damaged plaster/paint and examine the feasibility of repointing brickwork.
2. Replace any porous water-damaged building materials, once roof leaks are under control. Examine the area above and beneath these areas for microbial growth. Disinfect areas of water leaks with an appropriate antimicrobial. Clean areas of antimicrobial application when dry.
3. Continue working with HVAC vendor to make adjustments to the mechanical ventilation system to improve the comfort of occupants.
4. Repair breaches in the building envelope including, cracks in walls and tarmac, missing/damaged flashing, and spaces around bulkheads. Consider replacing damaged wooden bulkhead with metal.
5. Balance mechanical ventilation systems every five years, as recommended by ventilation industrial standards (SMACNA, 1994). Consult a ventilation engineer concerning re-balancing of the ventilation systems.

6. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
7. Consult “Mold Remediation in Schools and Commercial Buildings” published by the US EPA (2001) for information on mold. Copies of this document can be downloaded from the US EPA website at:  
[http://www.epa.gov/iaq/molds/mold\\_remediation.html](http://www.epa.gov/iaq/molds/mold_remediation.html).
8. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. These materials are located on the MDPH’s website at  
<http://www.state.ma.us/dph/MDPH/iaq/iaqhome.htm>.

## References

ACGIH. 1989. Guidelines for the Assessment of Bioaerosols in the Indoor Environment. American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

BOCA. 1993. The BOCA National Mechanical Code-1993. 8<sup>th</sup> ed. Building Officials & Code Administrators International, Inc., Country Club Hills, IL. M-1601 et al.

OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

SMACNA. 1994. HVAC Systems Commissioning Manual. 1<sup>st</sup> ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

US EPA. 2001. Mold Remediation in Schools and Commercial Buildings. US Environmental Protection Agency, Office of Air and Radiation, Indoor Environments Division, Washington, DC. EPA 402-K-01-001. March 2001.

**Picture 1**



**One of Three Air Handling (AHU) Units in the Attic**

**Picture 2**



**High-Efficiency Pleated Air Filters for AHU**

**Picture 3**



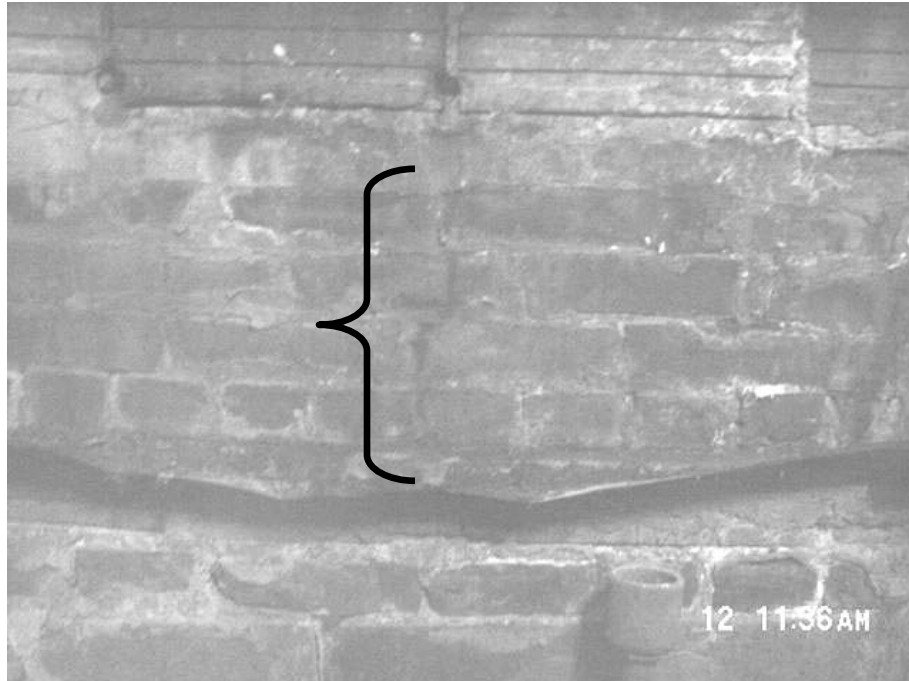
**Ceiling-Mounted Air Diffuser**

**Picture 4**



**Ceiling-Mounted Return Vent With High Efficiency Pleated Air Filter**

**Picture 5**



**Water Trickling Down Interior Brick Wall in Attic**

**Picture 6**



**Troughs Catching Water along North-Facing Wall in Attic, Note Water Damaged Floor Boards (Foreground)**

**Picture 7**



**Troughs Catching Water along North-Facing Wall in Attic,**

**Picture 8**



**Water Damaged Gypsum Wallboard Ceiling on Second Floor along North-Facing Wall**

**Picture 9**



**Water Damage/Peeling Ceiling Paint on Second Floor along North-Facing Wall**

**Picture 10**



**Exterior View of North-Facing Wall**

**Picture 11**



**Hole in Gutter/Missing Downspout**

**Picture 12**



**Missing Section of Downspout and Water Pooling on Exterior of Building**

**Picture 13**



**Open Hole in Exterior Brick**

**Picture 14**



**Missing/Damaged Mortar around Exterior Brick**

**TABLE 1**

**Indoor Air Test Results – Duxbury Free Library, 77 Alden Street, Duxbury, MA – January 12, 2005**

Location	Carbon Dioxide (*ppm)	Temp (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Background	333	40	50					Atmospheric Conditions: light drizzle, East winds 10-20 mph
Library Dir. Office	489	68	38	3	Y	Y	Y	
Administration	432	68	35	0	N	Y	Y	
Lanman Trustees Room	408	68	35	0	Y	Y	Y	
Attic								3 AHUs-pleated filters, elevated moisture/visible mold growth wood floor near North Wall, efflorescence-North Wall, troughs catching leaking water
Reference 800-900	529	71	27	0	Y	Y	Y	
Circulation Desk	540	71	27	2	N	Y	Y	
Oversize Stacks 001-696	500	72	28	22	N	Y	Y	
Non-Fiction 001-131	479	71	27	1	Y	Y	Y	

\* ppm = parts per million parts of air

**Comfort Guidelines**

Carbon Dioxide -	< 600 ppm = preferred 600 - 800 ppm = acceptable > 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

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Location	Carbon Dioxide (*ppm)	Temp (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Non-Fiction 973-999	568	71	28	2	Y	Y	Y	
Biographies A-Cho	473	70	27	2	Y	Y	Y	
Reference/Young Adult Office	504	70	28	1	N	Y	N	
Young Adult	498	70	28	0	N	Y	Y	
Study Room 2	463	69	28	0	Y	Y	Y	
Main Level Circulation Desk	487	70	28	1	N	Y	Y	
Circulation Office	527	72	27	1	N	Y	Y	Personal Fan blowing against exhaust
Children's Circulation Desk	473	72	27	1	N	Y	Y	
Children's Office	464	71	26	1	Y	Y	Y	
American History	440	71	26	0	Y	Y	Y	

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Fiction P-O	465	71	26	0	Y	Y	Y	
Videos	532	71	26	1	Y	Y	Y	
Picture Books	461	71	27	3	Y	Y	Y	
Fiction A-D	450	71	26	1	Y	Y	Y	
Mystery Mori to Stou	507	71	27	1	Y	Y	Y	
Mystery Mori to Zuko	555	71	27	0	Y	Y	Y	
Periodicals	459	71	27	1	Y	Y	Y	
Video/DVD	450	70	27	1	Y	Y	Y	
Children's Program Room	488	70	28	0	Y	Y	Y	
Setter Room	395	68	28	0	Y	Y	Y	

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						Supply	Exhaust	
Kitchen	477	70	29	0	N	Y	Y	
Merry Meeting Room	444	71	29	0	Y	Y	Y	
Rear Foyer								Snow Blower stored inside
Perimeter of Building								Missing/damaged mortar around brick, missing downspouts water pooling/back splashing

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